Technology considerations: IGCC vs SCPC

Introduction

This paper reviews recent reports which examined the cost of both supercritical pulverized coal (SCPC) technology and integrated gasification combined cycle (IGCC) technology. The report draws general conclusions regarding both the relative capital cost and levelized cost of electricity from power plants using these technologies, the approximate cost-effectiveness of SO2 and NOx control from SCPC plants, and the marginal cost-effectiveness of controlling these pollutants using IGCC instead of SCPC.

Source studies for cost

Several studies have been completed over the past year examining the cost of power from SCPC and IGCC technologies, for US markets. In comparing these two types of technologies, it is important to use analyses that examined both technologies in the same study, using assumptions as similar as possible. Otherwise, differences in methodology between studies can mask the differences in technology.

Table 1 presents capital and operating cost data from four studies completed in 2006, as well as a 2002 study included for perspective. An additional report by the Wisconsin Energy Center, which did not include detailed cost data, is included for its perspective on the state of IGCC technology. Excluding the 2002 report, the range of capital cost in these reports was approximately $1670-2670/kw for IGCC, and $1431-2190/kw for SCPC. Each individual report considered power plants of about the same size, using the same fuel, but between the reports the plant generating capacity, coal rank, and certain other parameters varied. Hence, it is also useful to consider the ratio of capital costs between the IGCC and SCPC technology in each report. This ratio ranged from 1.12 to 1.22 for the four reports prepared in 2006. For the three reports that included cost of electricity (COE) calculations, the ratio of the COE for IGCC versus SCPC ranged from 1.10 to 1.15. Relevant comments regarding each of the reports are keyed in the final column of Table 1, and listed following the table.

Table 1. IGCC and SCPC costs.

Study	Technology	Capital Cost (Total Capital Requirement), $/kw	Fixed O&M, $/kwyr	Variable O&M, $/mwh	Comments
WI Energy Center[1]	IGCC	Na	Na	Na	a
NETL Parsons[2]	IGCC	1374	5.2[b]	0.3	b
	SubCPC	1268	5.1[b]	0.9	
EPRI CPS[3]	IGCC	2670	25.19	5.95	c
	SCPC	2190	20.68	4.60	
EPA[4]	IGCC	1670	0	7.34	d
	SCPC	1431	0	7.79	
NETL Klara[5]	IGCC	1692	na	na	e
	SCPC	1508	na	na	
WI PUC[6]	IGCC	1872	34.2	2.58	f
	SCPC	1628	24.0	3.00	

a. Reliability: "IGCC is an immature technology when compared to NGCC and pulverized coal." "IGCC is ready for large scale demonstration and early adopter investment (supplemented by significant government assistance)." Gasifier availability rates cited for 5 IGCCs in 2004 paper ranged from 69-82%.
b. Study assumptions: 397 MW Pulverized Coal (PC) unit, 1st Q 2002 $'s; Debt-to-equity ratio (D/E) = 80%/20%; Cost of capital (Discount Rate) = 7.9% in constant dollars, 11.2% in current dollars; Inflation = 3%/yr; Real escalation (over inflation) = -1.1%/y for fuel, 0 for O&M. Fixed O&M (FOM) is in $/mwh. IGCC is Destec (Conoco-Philips) design, and 400 MW. 85% capacity factor assumed. IGCC Variable O&M (VOM) offset by

[1] IGCC Engineering and Permitting Issues Summaries, Clean Coal Study Group, Energy Center of Wisconsin, April 2006.
[2] Advanced Fossil Power Systems Comparison Study, National Energy Technology Lavoratory / Edward Parsons, December 2002.
[3] Feasibility Study for an IGCC Facility at a Texas Site, Final Report, CPS Energy, EPRI, September 2006. Availability assumed to be 85% for IGCC, 90% for SCPC, but 85% capacity factor was used for economic analysis of both. Levelized 2006 dollar COE was: IGCC – 45.03 $/mwh; SCPC – 40.89 $/mwh.
[4] Environmental Footprints and Costs of Coal-Based IGCC and PC Technologies, EPA-430/R-06/006, July 2006.
[5] IGCC: Coal's Pathway to the Future, presentation by J.Klara, NETL, at Gasification Technologies Council Conference, October 2006.
[6] IGCC Draft Report, Wisconsin PUC, June 2006.

-0.6 $/mwh credit for By-product sales. Efficiency, based on lower heating value (LHV) was 38.9% for PC and 46.7% for IGCC.

c. Study Assumptions: Study was based on a Subbituminous coal system in Texas, and assumed some accommodation for future retrofits for CO2 capture. Capital costs are "Total Project Costs".
d. Study Assumptions: 500 MW capacity units; Costs in 4th Q 2004 dollars; capacity factor = 85%. IGCC:41.8% efficiency. SCPC: 38.3% efficiency. Operating costs taken from earlier studies and updated. Total O&M expressed as VOM in chart.
e. Study Assumptions: Jan 2006 Dollars, 13.8% levelization factor. IGCC is an amalgam of GE, E-Gas, and Shell systems, 625 MW, Cost of electricity = 54.8 $/mwh, capacity factor = 80%. PC COE= 49.7 $/mwh, capacity factor = 85%.
f. Study Assumptions: SCPC: 600MW, 85% Capacity factor, 38.6% efficiency. IGCC: 600MW, 80% Capacity factor, 39.2% efficiency. PC data based on Elm Road Generating Station; IGCC based on projected costs.

Source studies for emissions

Emission estimates for IGCC systems systems are taken from recent permit applications and presentations at technical conferences. EPA or state permit emission estimates for SO2 and NOx were available for the ERORA IGCC's proposed for Taylorville, IL, and Cash Creek, KY, and the Southern Illinois Clean Energy Center at Steelhead, IL. Additional data, deemed less reliable, was available from conference presentations for Duke Energy in IN, Excelsior Energy in WI, Energy Northwest in WA, and Southern Co. in FL. The average emission rates from the three available permits for SO2 and NOx were 0.037 and 0.045 #/mmBtu for SO2 and NOx respectively. Including the information reported at conferences resulted in averages of 0.03 #SO2/mmBtu and 0.04 #NOx/mmBtu. For purposes of this analysis, the permit data was used because it was considered more reliable.

Emissions for the Pee Dee unit were based on the BACT and air quality permit analysis, and ranged between 0.11- 0.15 #SO2/mmBtu and 0.06 - 0.07 #NOx/mmBtu, for different averaging periods. The lower end of these ranges was calculated from tonnage caps. For purposes of this analysis, the most restrictive limit was used.

The cost-effectiveness of the Pee Dee unit emission reductions for SO2 and NOx was calculated using IECM, a model developed by Carnegie Mellon University for USDOE's National Energy Technology Laboratory.[7] Using inputs approximating conditions at the Pee Dee unit, the cost-effectiveness of control was 220 $/ton SO2, and 1500 $/ton NOx (levelized 2006 dollars).

[7] Integrated Environmental Control Model (IECM), NETL & Carnegie Mellon University, http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/cmu-iecm.html .

Discussion

In general, the reports cited above are the best comparative analyses of IGCC and SCPC that are publicly available. Nevertheless, they are at best a "snapshot" of a moving target. As noted in the EPRI report, for example, the current marketplace for power plants is one which reflects shortages in skilled construction labor and dramatic increases (100-300%) in commodity prices over the past few years – in other words, a relatively volatile "seller's market". As a result, the cost projections in these reports are imprecise, and may not apply directly to the Santee Cooper situation. For example, Santee Cooper may be able to achieve some cost savings for a SCPC design because it is similar to one with which they have existing experience (the Pee Dee units are similar to the Cross units now under construction).

In addition, several of the above studies noted the lower reliability of IGCC compared to SCPC systems, generally citing about a 5% difference in availability or capacity factor. However, their treatment of this issue varied. For example, the NETL study used a different capacity factor in calculating cost of electricity, while the EPRI study cited the difference in availability, but used the same capacity factor in calculating COE for the two designs. Neither approach adequately reflects the fact that there is apt to be a learning curve for using a new IGCC, with reliability improving over time, whereas the conventional SCPC unit will probably reach optimal performance in its first year of operation.

On the other hand, Santee Cooper is a State chartered utility which uses 100% debt financing and has a lower cost of capital than the investor owned utilities assumed for most of the cited studies. This would tend to result in a lower COE for Santee Cooper than that calculated in most of those studies.

Based on the cited studies and discussion above, and including an adjustment for a 5% higher availability from the SCPC system, the cost of electricity from an IGCC is estimated to be 15% greater than from a SCPC system. Assuming a net capacity of 600MW, this results in an additional annualized cost of $24 million for the IGCC design versus the SCPC design.

The difference in emissions between the amalgam of proposed IGCC plants (adjusted to match the capacity of Pee Dee) and the Pee Dee SCPC unit was 1444 tpy SO2 and 290 tpy NOx. Dividing the incremental power plant cost by the sum of these two emission differences resulted in a marginal cost-effectiveness of 13,900 $/ton of pollutant reduction.

Conclusions

Both IGCC and SCPC can be equipped for highly effective reduction of SO2 and NOx emissions. IGCC tends to have somewhat lower emissions of these two pollutants. However, two key factors make the choice of IGCC undesirable from

Santee Cooper's perspective. First, even recent studies of IGCC cite the immaturity of this technology, and the fact that existing units, and several proposed units, were significantly subsidized by government incentives or cost sharing. The technology does not have the reliability of traditional SCPC systems, and reliability is of critical importance to Santee Cooper.

Second, the cost of power from IGCC is estimated to be 15% more than SCPC systems. If the higher cost of IGCC systems is interpreted as a cost of control for SO2 and NOx, then this marginal cost effectiveness of control is substantially higher than costs typical for SO2 and NOx control at coal-fired power plants, an order of magnitude above the cost effectiveness estimated above for the proposed Pee Dee unit, and an order of magnitude above the market price for SO2 and NOx allowances. This significantly higher cost of control is a legitimate basis for not selecting the more expensive of two highly effective emission control approaches under top-down BACT.

For these reasons, Santee Cooper has selected the SCPC system for the Pee Dee unit.